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Method and apparatus for removing gas from particulated material

The present invention concerns a method for removing gas from particulated or comminuted material, especially from material including lignocellulose, like chipped wood. The invention also concerns an apparatus for carrying out the method. Gas in this connection refers to air present in the free space between the chips and in voids inside the chips, as well as other gases, mainly originating from the material to be processed.

Gas removal from chipped wood to be transported to chemical or chemi-mechanical pulping has a great impact on the quality of the wood pulp produced by the defiberization. Gas removal from the intermediate spaces between the chips decreases the amount of air coming to the pulping stage. The removal of gas from the voids inside the chips enhances the impregnation of the pulping chemicals into the chips. The air removal is conventionally implemented by heating the chips by means of steam.

Vertical silos or horizontal screws are generally used for removing gas from the chips by steam treating of the chips. The chips are fed into the silo through its upper end and the steamed chips are removed from the lower end of the silo. The steam is supplied to the lower part of the silo and it flows upwards, against the direction of movement of the chip material. Disturbances in the flow-ability of the chips to be processed occur in the vertical silos, like formation of arcs and deposits. As a result from the uneven flow of the chips, the lengths of the treatment times for different chip pieces vary. Distribution of the steam evenly to the chips is difficult, especially in big silos. The chip volume of the silo is constant, whereby the process time of the chip pieces changes with changing production.

When essentially in horizontal position operating screw conveyors are used in apparatuses for removing gas from chips, it has been noted that the chip filling factor of the screw is low, and the retention times of the chips in the apparatus vary. Realization of an adequately long processing time in a screw operated apparatus would require an impractically large screw. The time required to reach the intended treatment temperature of the chips is long both in silos and in screw operated apparatuses, thus shortening the processing time at the maximum temperature on a given output of the

apparatus. The gas removal from inside a chip piece is efficient only at elevated temperatures, and consequently the best results are not achievable when a silo or a screw operated apparatus is used for gas removal.

The U.S. Patent 4,592,804 discloses a method and an apparatus for pretreatment of lignocellulose material like wood chips. The patent describes an apparatus comprising a silo, conveyors, steam inlets and condensate removal outlets. Chips are discharged from the chip silo to a horizontal conveyor. Steam is supplied to the chips through the bottom of the conveyor section in the apparatus, while the chips are advancing on the conveyor section. The formed condensate is separated from the chips through the discharge outlets located in the conveyor section.

The Patent Application Publication WO 98/35089 discloses a method and an apparatus for pre-steaming and impregnation of material containing cellulose. The chips are steamed in a downwards enlarging silo and in a subsequent conveyor screw. After the heating, the air removal from the chips is emphasized by leading the chips into a space having a lower pressure than the space used for heating.

U.S. Patent 4,867,845 discloses a downward enlarging silo for steaming cellulose containing material. The chips are removed from the silo by means of a rotary unloader. Steam is supplied through a pipe having a conically expanding portion at its lower part.

U.S. Patent 6,199,299 discloses a chip silo to be used for pretreatment of comminuted cellulose material, and for feeding the same to a pulping process.

In the research "Modelling air removal from chips" by K. Kovasin, (The 4th Biennal Johan Gullichsen Colloguium, Sept. 10. 2003, pp. 55-62) is stated that the treatment time of a chipped piece has a remarkable influence on the removal of the air from inside the chips. When the length of the chip piece is 25 mm, treatment temperature is 100°C and treatment pressure is 101 kPA there will be 50 % air left after a treatment of 10 minutes and 30 % after a treatment of 20 minutes. In the modern continual digesters the retention time in the steaming vessels is typically from 10 to 15 minutes and treatment temperature from 100 to 120°C. Air removal up to 90 % would demand a treatment time of 30 minutes.

Sergey Malkov, Panu Tikka, Valeri Kuzmin and Vladimir Baltakhinov in their article "Nordic Pulp and Paper Research Journal", Vol. 17, no 4/2002, pages from 420 to 426, state, that complete removal of air from chips can be achieved, when the partial steam pressure inside the chips is equal to the pressure in the space around them.

The object of the present invention is to provide a method for removing gas from comminuted lignocellulose material. This is based on a new technique, wherein the temperature of the material in a heating stage, where the material is advancing as a gravitationally lowering column, is raised efficiently and quickly into a temperature determined for an efficient gas removal from the material in question. The heating is performed introducing to the material efficiently steam so that the steam is crossing the travel path of the lowering material column. Most preferably the steaming is effected by introducing steam both from the middle of the column and from its periphery. The required temperature is determined in accordance with the material to be degasified taking into account its quality and state. For the heating treatment the steam supply is to be intensive in order to elevate the temperature of the material particles almost completely to the temperature selected for the degasifying treatment for the material in question. As a minimum for the energy supply as heating steam is about 70% of the total heating energy required to keep the material at the selected temperature during the degasifying process, i.e. only about 30% more steam energy is required in the subsequent treatments to preserve the material at the intended temperature. A preferred proportion consumed in the heating state is about 90% of the total steam energy required for the complete degasifying treatment. It has been shown in the pilot tests that the chips can be heated up to the gas removal temperature quickly, when an adequate amount of steam is supplied as an even flow to the chips.

The material is then subsequently to the heating kept at a selected elevated temperature a certain retention time, while transporting it through a gas removal stage as a composed bed (disturbance as minimal as possible). In the gas removal stage additional steam is supplied to the material in order to maintain the treatment temperature selected for the gas removal for the actual material. Gases, released from the material under treatment, are removed from the upper part of the heating section and the gas removal section, from above the surface of the material. The formed condensate is removed

from the bottom of the heating section and the gas removal section. In the method in accordance with the invention, all material particles receive equal treatment (heating and degasification). The steam flow supplied in the transversal direction to the material flow during the temperature rising does not disturb the lowering material column. When a temperature over 100 °C is used for the degasifying treatment, a pressure essentially of or slightly higher than the steam pressure at such temperature, is maintained in the gas removal stage by allowing a controlled gas escape through gas outlets connected to the gas removal stage.

The method in accordance with the invention can be implemented with an apparatus comprising, an upright silo provided with supply of material and steam and removal of gas, a longitudinal vessel connected at one end to the lower part of the silo. The longitudinal vessel is furnished with, means for conveying the material trough the vessel as a composed bed and means for removing the material from its second end. The silo is here referred to as heating section and the longitudinal vessel as gas removal section. The vessel is a tube-like construction positioned horizontally or slightly downwards inclined. The vessel has a longitudinal dimension bigger than the cross-dimension and includes means for transporting material through the vessel. The conveying means are positioned in the lower part of the vessel and extend essentially along its total length. Steam supplying conduits are provided along the length of said vessel. Also conduits for gas and condensate removal are provided.

The invention will be described in more detail in the following with reference to the enclosed drawings, wherein

Figure 1 illustrates as a cross sectional view one embodiment of the apparatus applicable in practicing the invention,

Figure 2 illustrates as a side view an alternative embodiment of the apparatus, and

Figure 3 illustrates the embodiment of figure 1 as a cross sectional view.

The basic part of the apparatus shown in figure 1 is a longitudinal vessel 1, located horizontally. The vessel 1 is referred to as gas removal section. The length of the vessel is bigger than the cross-sectional dimension thereof. The vessel 1 is equipped with

conveyor means 3 extending over its total length for transporting the bed of material fed to it from the first end of the vessel to the opposite end thereof. One embodiment of the conveying means is described in more detail in figure 3.

The apparatus comprises further a heating section 2, which is an upright cone, enlarging downwards. The apparatus include also means for feeding the material to be treated into the vessel, said means being defined in general with reference numeral 4. The heating part 2 is positioned at an angle of 90° with respect to the vessel 1. On the opposite end of the vessel 1 there are means for removing the treated material from the vessel, said means being defined in general with numeral 30. Conveyors for feeding the material into the silo 2 and for removing it from vessel 1 are not illustrated.

In an embodiment of the apparatus in accordance with Figure 1, the material feeding means 4 are formed by a silo or a tower, through which the material fed to its upper part travels vertically downwards by gravity. The heating section 2 comprises a supply pipe 5 for supplying steam into the middle of the heating section. The lower end of the supply pipe 5 comprises a sieve 6 for dividing the steam from the pipe evenly to the material, horizontally a whole circle. In the mantle of the heating section, located at the same level with the sieve 6, there is a sieve 7 extending around the whole mantle for supplying steam to the material horizontally around the whole heating section. The sieve 7 comprises one or a plurality of inlets 8 for feeding steam, and a distribution chamber 9 located around the whole heating section for distributing steam evenly around the circle of the whole heating section. The heating section additionally comprises one or a plurality of outlets 10 for removing the gas displaced by the steam from the gas space 11 above the material surface 14. In addition, there is one or a plurality of outlets 12 below the heating section, for removing the formed condensate.

On the bottom of the gas removal section 1 there are conveyor means 3 for transporting the material bed through the gas removal section. The speed of the conveyor can be adjusted. At the first end of the gas removal section, on the upper part thereof, there is an adjustment stop 16 defining the height and form of the upper surface 22 of the material bed fed to the gas removal section. By adjusting the position and form of the adjustment stop 16 the height and form of the upper edge 22 of the material bed can be adjusted. The adjustment stop 16 is gas-tight and seals the gas space 17 of the gas

removal section so, that the pressure therein can be higher than in the heating section. The gas removal section has an outlet 18 for removing the gas released from the material, an outlet 19 for removing the formed condensate and an inlet 20 for supplying steam to the gas removal section. The amount of the outlets and inlets 18, 19 and 20, respectively can be one or a plurality. At the tail end of the treatment section 1 there are means 30 for removing the material from the apparatus in accordance with the invention. When the chip production, measured as cubic meters per hour, changes, the retention time of the chip bed in the gas removal section can be kept at desired value by changing the chip bed height by adjusting the vertical position of adjustment stop 16 and keeping the conveyor 3 speed constant.

The gas removal section has an outlet 18 for removing the gas released from the material, an outlet 19 for removing the formed condensate and an inlet 20 for supplying steam to the removal section. The number of the outlets and inlets 18, 19 and 20, respectively can be one or several. At the tail end of the treatment section 1 there are means 30 for removing the material from the apparatus in accordance with the invention.

The retention time of the material to be treated, in the gas removal section 1, can be adjusted by changing the transferring speed of the conveyor 3.

The moisture content and initial temperature of the material to be heated have influence on the need of energy for the heating. Physical and geometrical properties of the material to be heated have influence on the heating speed of the material. Also the temperature of the steam to be used has influence on the heating result. In the method in accordance with the method, the material is heated in the heating section 2 to a temperature ranging from 80 to 160°C, preferably from 100 to 130°C. The retention time of the material in the heating section ranges from 20 to 180 seconds. The portion of the steam supplied to the heating stage is more than 70 % of the steam supplied to the whole apparatus, preferably more than 90 %.

The heated material continues from the lower part of the heating section 2 traveling through the gas removal section 1, transported by the conveyor means 3 on the bottom thereof. The material becomes compressed during the travel through the heating section

2 and it is led through the gas removal section 1 as a dense and composed bed. Thus, the treatment exerted to each material particle becomes almost equal and as a result of that, the gas removal from the material is efficient. The time required for discharging the gas from inside the material pieces depends on the size and properties of the material pieces. In the method in accordance with the present invention the retention time of the material in the gas removal section 1 ranges from 10 to 65 minutes, preferably from 15 to 25 minutes, depending on the temperature used for the degasifying treatment.

The steam used for the heating of the material can be either fresh steam or steam flashed from another sections of a pulping process. The steam included in the gas discharged from the heating stage and the gas removal stage can be recovered and reused compressed for heating purposes.

Figure 2 shows as a schematic side-view an alternative embodiment of the apparatus. In said figure, the part numerals from 1 to 30 refer to the equal parts as in figure 1. In the embodiment of figure 2, the conveyor means 3 is located extending only over the area of the first part of the gas removal section. The material bed travels through the end part 31 of the gas removal section pushed by the conveyors of the first part. The end part 31 of the gas removal section is arranged downwards inclined in the direction of flow of the material bed, which reduces the power needed for the transportation thereof.

Figure 3 shows a cross sectional view at A-A of Figure 1. Figure 3 illustrates one way to transfer the material through the gas removal section 1 by means of a conveyor disclosed in patents FI 83181 and FI 109103.

The conveyor apparatus comprises narrow and long parallel lamellas 31 supported by supporting rolls. The lamellas 31 extend parallel with the longitudinal axis of the gas removal section 1 over its total length. The lamellas are equipped with driving means for moving them in the longitudinal direction for a defined length back and forth. The movement of the lamellas in the direction of travel of the material is significantly slower than that of their return movement. With this arrangement, a bigger portion of the lamellas is moving in the proceeding direction than in the return direction. As a net

result, the material is advancing in the gas removal section 1. When the lamellas 31 are arranged as shown in figure 3, on the bottom of the gas removal section 1 in a semi-circular form arrangement, the material to be treated tends to pack towards the central area of the gas removal section. This decreases the friction on the side walls and helps the material to proceed as an even and composed bed.

The steam is supplied from the inlet 20, and the steam flows to the material to be treated through the gaps between the lamellas 31 as shown by the arrows. Condensate is formed in the heating section 2 and in the gas removal section 1 as the heating steam is condensed. The condensate flows to the lower part of the chip space on top of the lamellas 5 and is removed through the outlet 12 as shown by the arrows.

It is evident for those skilled in the art, that the transportation of the material bed through the gas removal section 1 can also be implemented with other conveyor constructions, known in the art, than that shown in figure 3. For example stoker chain conveyors can be used, wherein transversal bars movable in the proceeding direction, are pulled by chains. Different requirements are set by different conveyor devices to the design of the bottom of the gas removal section. In some cases the bottom must be plain.

With the arrangements described above, an efficient gas removal from material containing lignocellulose and comminuted into pieces is provided. The material is heated efficiently to a gas removal temperature by means of direct steam supplied across the material flow. The steam across the material flow does not cause any disturbances to the flow of the material, whereby the whole lot of material is heated evenly to the desired gas removal temperature. With a rapid and effective heating, a longer treatment time in the subsequent gas removal stage remains on a certain capacity of the apparatus. The material to be treated is transported through the gas removal part as a composed bed. Thus, each of the chips is subjected essentially to a treatment of an even efficiency. With the apparatus in accordance with the invention, the treatment time of the material can be adjusted according to the quality of the material, or, alternatively, the treatment time can be kept constant as the volume of the production changes.

Compared with the methods of prior art, the present invention is preferred therein, that with the method in accordance with the invention, the gas inside the material pieces can be efficiently removed. This gas removal enhances the impregnation of digesting chemicals into the material pieces. The effect of the enhanced impregnation is shown by the improved quality of the cooked pulp.